FINAL
HAZARD RANKING SYSTEM
DOCUMENTATION RECORD

for

RAVENSWOOD PCE GROUND WATER PLUME
RAVENSWOOD, JACKSON COUNTY,
WEST VIRGINIA
(EPA ID No. WVSFN0305428)

Prepared for:
U.S. ENVIRONMENTAL PROTECTION AGENCY – REGION III
PHILADELPHIA, PENNSYLVANIA

SUPERFUND TECHNICAL ASSESSMENT AND RESPONSE TEAM (Western Area)

Contract No.:	68-S3-00-01
TDD No.:	SW3-02-07-0015
Date Prepared:	March 2003
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HRS DOCUMENTATION RECORD--REVIEW COVER SHEET

Name of Site: Ravenswood PCE Ground Water Plume
EPA ID No.: WVSFN0305428

Contact Persons

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Pathways, Components, or Threats Not Scored

The surface water migration, soil exposure, and air migration pathways were not scored in this documentation record because these pathways are not expected to significantly contribute to the overall site score. No air samples have been collected to document a release to ambient air.

HRS DOCUMENTATION RECORD

Name of Site: Ravenswood PCE Ground Water Plume CERCLIS ID No.:WVSFN0305428

EPA Region: 3 Date Prepared: March 2003

Street Address of Site: City of Ravenswood (Ground Water Plume)

County and State: Jackson County, West Virginia

General Location in the State: Western portion of West Virginia, along Ohio River

Topographic Maps: Ravenswood, West Virginia-Ohio, 1994, and Sandyville, West Virginia, 1960 (Photo revised 1988) (References 5 and 6)

Latitude: 38° 57' 6" north Longitude: 81° 45' 42" west

Geographical coordinates were determined from the location of Municipal Well 3 (References 5, 6, and 33).

	Scores
Ground Water Pathway	100
Surface Water Pathway	Not Scored
Soil Exposure Pathway	Not Scored
Air Pathway	Not Scored
HRS SITE SCORE	50.00

WORKSHEET FOR COMPUTING HRS SITE SCORE

		S	S^2
1.	Ground Water Migration Pathway Score (S_{gw}) (from Table 3-1, line 13)	100	10,000
2a.	Surface Water Overland/Flood Migration Component (from Table 4-1, line 30)	NS	
2b.	Ground Water to Surface Water Migration Component (from Table 4-25, line 28)	NS	
2c.	Surface Water Migration Pathway Score (S_{sw}) Enter the larger of lines 2a and 2b as the pathway score.	NS	
3.	Soil Exposure Pathway Score (S_s) (from Table 5-1, line 22)	NS	NS
4.	Air Migration Pathway Score (S_a) (from Table 6-1, line 12)	NS	NS
5.	Total of $S_{gw}^2 + S_{sw}^2 + S_s^2 + S_a^2$		10,000
6.	**HRS Site Score** Divide the value on line 5 by 4 and take the square root	50.00	

NS = Not scored
S = Pathway score
S^2 = Pathway score squared

Site Name: Ravenswood PCE Ground Water Plume **FINAL**
Location: Ravenswood, Jackson County, West Virginia

GROUND WATER PATHWAY SCORESHEET

		Maximum	Assigned
Likelihood of Release to an Aquifer:			
1.	Observed Release	550	550
2.	Potential to Release		
2a.	Containment	10	10
2b.	Net Precipitation	10	
2c.	Depth to Aquifer	5	
2d.	Travel Time	35	
2e.	Potential to Release [lines 2a(2b+2c+2d)]	500	
3.	Likelihood of Release (higher of lines 1 and 2e)	550	550
Waste Characteristics:			
4.	Toxicity/Mobility	(a)	100
5.	Hazardous Waste Quantity	(a)	100
6.	Waste Characteristics	100	10
Targets:			
7.	Nearest Well	50	50
8.	Population:		
8a.	Level I Concentrations	(b)	31,642.8
8b.	Level II Concentrations	(b)	0
8c.	Potential Contamination	(b)	521.4
8d.	Population (lines 8a+8b+8c)	(b)	32,164.2
9.	Resources	5	0
10.	Wellhead Protection Area	20	20
11.	Targets (lines 7+8d+9+10)	(b)	32,234.2
Ground Water Migration Score for an Aquifer:			
12.	Aquifer Score [(lines 3x6x11)/82,500] c	100	100
Ground Water Migration Pathway Score:			
13.	Pathway Score (Sgw), (highest value from line 12 for all aquifers evaluated)c	100	100

a Maximum value applies to waste characteristics category.
b Maximum value not applicable.
c Do not round to nearest integer.

A copy of *Figure 1* is available at the EPA Headquarters Superfund Docket:

Public Reading Room, Room B102
EPA West Building
1301 Constitution Avenue, NW
Washington DC 20460

Telephone: (202) 566-1744
E-Mail: superfund.docket@epa.gov

A copy of *Figure 2* is available at the EPA Headquarters Superfund Docket:

Public Reading Room, Room B102
EPA West Building
1301 Constitution Avenue, NW
Washington DC 20460

Telephone: (202) 566-1744
E-Mail: superfund.docket@epa.gov

REFERENCES

Reference Number	Description of the Reference
1.	U.S. Environmental Protection Agency (EPA), *Hazard Ranking System*, 40 CFR Part 300, Appendix A, 55 FR 51533, December 14, 1990.
2.	U.S. Environmental Protection Agency, *Superfund Chemical Data Matrix*, Appendix B, January 28, 2004. 34 pages (excerpt).
3.	Letter from Newell, D., State of West Virginia Department of Health and Human Resources, to Nance G., Ecology & Environment, Inc., Charleston, WV. Wellhead Protection Map. July 24, 2002.
4.	U.S. Environmental Protection Agency, *USEPA Contract Laboratory Program Statement of Work For Analysis of Low Concentration Organic OLC03.2,* December 2000. 13 pages (partial copy)
5.	U.S. Geological Survey (USGS), 7.5-minute Series Topographic Quadrangle Map of West Virginia, Sandyville 1960 (Photo revised 1988); scale 1:24,000.
6.	U.S. Geological Survey (USGS), 7.5-minute Series Topographic Quadrangle Map of West Virginia-Ohio, Ravenswood 1994; scale 1:24,000.
7.	Triad Engineering, Inc., Sampling and Analysis Plan, Quality Assurance Project Plan, IDW Plan for Ravenswood PCE CERCLA Site, submitted to West Virginia department of Environmental Protection, March 13, 2002. 47 pages.
8.	West Virginia Geological and Economical Survey, Geologic Maps of West Virginia, East and West Sheets (2 maps), 1968 (Slightly revised 1986); 1:250,000.
9.	Roy F. Weston, Inc., Site Inspection Narrative Report, submitted to U.S. EPA, Region III. January 14, 2000. 184 pages.
10.	Lockheed Martin, Response Engineering and Analytical Contract (REAC), Drilling Report for Field Activities at the Ravenswood Site, submitted to U.S. EPA/Environmental Response Team Center (ERTC). August 19, 1999. 38 pages.
11.	Pollution Report No. 2 (Soil Gas Investigation Report), Ravenswood PCE, Ravenswood, Jackson County, West Virginia. March 5, 1999. 2 pages.

12. Pollution Report No. 23 (Soil Gas Investigation Report), Ravenswood PCE, Ravenswood, Jackson County, West Virginia. May 21, 1999. 2 pages.

13. Roy F. Weston, Inc., Ravenswood PCE Site - Sampling Plan, submitted to U.S. EPA, Region III. August 20, 1999. 9 pages.

14. Frost Associates. Population and Well data for the Ravenswood PCE Site, Ravenswood, Jackson County, WV (Site Coordinates: 81° 45' 39.5" W, 38° 57' 2.9" N). November 12, 1999. 8 pages.

15. Norman, E.M. City of Ravenswood, West Virginia, *Well Field Report*. July 14, 1997. 20 pages.

16. U.S. Environmental Protection Agency Region III, Office of Analytical Services and Quality Assurance, Fort Meade, MD. Analytical Report, Ravenswood PCE, Lab Request # REQ00046. February 14, 2000. 16 pages.

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18. U.S. Environmental Protection Agency Region III, Office of Analytical Services and Quality Assurance, Fort Meade, MD. Analytical Report, Ravenswood PCE, Lab Request # REQ00079. April 3, 2000. 15 pages.

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20. U.S. Environmental Protection Agency Region III, Office of Analytical Services and Quality Assurance, Fort Meade, MD. Analytical Report, Ravenswood PCE, Lab Request # REQ00117. June 1, 2000. 15 pages.

21. GAI Consultants, Inc., Interim Investigation Report, Ravenswood PCE Site, Ravenswood, West Virginia, submitted to West Virginia Division of Environmental Protection - Office of Environmental Remediation (WVDEP - OER). July 13, 2001. 35 pages (partial copy-does not include all figures and drawings)

22. Triad Engineering, Inc., St. Albans, WV, Field Book for Ravenswood PCE Expanded Site Inspection, March 27 to April 1, 2002. 26 pages.

23. Telephone conversation between Nance, G., Ecology & Environment, Inc., and Pence, S., Jackson County West Virginia School Board, School Populations, October 21, 2002. 1 page.

24. Burger, R., Weston, SATA, Wheeling, WV. Ravenswood Site Logbook (SATA03A01263), Page 17. May 19, 1999. 2 pages.

25. Telephone conversation between Nance, G., Ecology & Environment, Inc., and Turner, J., City of Ravenswood, Drinking Water Service, July 25, 2002. 1 page.

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27. Telephone Conversation between Dr. Singh, RAI, and Cambarare, V., Chief Operator, City of Ravenswood. Municipal Water Wells. January 9, 2001. 1 page.

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30. Fax transmittal from Downie, J., U.S. EPA, Region III, to Peter Gold, U.S. EPA. Ravenswood PCE Site Map showing location of soil gas samples near water plant. May 28, 1999. 2 pages.

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33. Latitude and Longitude Calculation Worksheet #1, Preliminary Assessment Guidance. Voss, C., Resource Applications, Inc., January 11, 2001. 1 page.

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41. Sample Quantitation Limit (SQL) Calculations. Nance, G., Ecology & Environment, Inc. February 10, 2003. 1 page.

42. U.S. Environmental Protection Agency, EPA Publication SW-846*, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, *Method 8260B Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)*, *Revision 2,* December 1996. 3 pages (partial copy).

43. Telephone Conversation between Nance, G., Ecology & Environment, Inc. and Ericson, R., REI Consultants, Inc., Analytical Methods for Ravenswood Sample Analysis. February 4, 2003. 1 page.

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Site Description

The Ravenswood PCE Ground Water Plume Site consists of a ground water plume within the unconfined Quaternary Alluvium aquifer (Reference 8; Reference 9, pages 9-08, 9-09, and 9-11; Reference 21, pages 21-07, 21-09, and 21-12). Analytical results for three of the City's five municipal wells have indicated tetrachloroethene (PCE) contamination ranging up to 91.4 micrograms per liter (: g/L) or parts per billion (ppb) (Reference 21, page 21-07 and Table 1 [pages 21-29, 21-30]). Contamination has been detected in Municipal Well Nos. 2, 3, and 5 (Reference 9, pages 9-09 and 9-16; Reference 21, pages 21-09, 21-29, and 21-30). Two of the municipal wells (Wells 2 and 3) are located in the City Maintenance Building. All of the municipal wells are located within an approximately three- to four-acre area to the north of the downtown area. The City Maintenance Building is bounded on the north by an open grassy area, with the adjacent Ravenswood High School located to the north and east, and Plaza Drive located beyond; on the south, by an asphalt parking area with the Jackson County Public Library located beyond; on the east, by the Ravenswood High School baseball field; and on the west, by Virginia Street (Reference 21, pages 21-5 and 21-6); also refer to Figures 1 and 2 of HRS documentation record).

The City Maintenance Building that houses Municipal Wells 2 and 3 was formerly an electrical power plant owned and operated by the City of Ravenswood (Reference 9, page 9-08; Reference 21, page 21-10). Following closure of the power plant, the building was converted into the City Maintenance Garage (Reference 21, page 21-10). PCE may have been used as a cleaning solvent when the electrical power plant was in use (Reference 21, page 21-10). Municipal Wells 1 through 4 were constructed between 1939 and 1964. Municipal Well 5 was constructed in 1977 (Reference 15, pages 15-03 and 15-15; Reference 21, page 21-06).

The blended water supply system for the City of Ravenswood supplies drinking water to a population of 5,453.2 persons in Ravenswood, which includes residential population of approximately 4,005.2 persons and 1,448 students, faculty, and staff from three schools (Reference 23, page 23-01; Reference 25, page 25-01; Reference 26, page 26-01; Reference 34, page 34-03). In addition, the system also supplies water to approximately 2,478.5 persons in the Silverton PSD, which includes the population of two elementary schools (Reference 34, page 34-02; Reference 35, page 35-01; and Reference 36, page 36-01).

Well 3 has consistently shown the highest level of PCE contamination for the municipal wells. In September of 1998, the City of Ravenswood shut down Municipal Well 3 due to PCE contamination (Reference 21, page 21-09). Records indicate that PCE concentrations increased in Well 3 from 6 ppb in October 1989 to 73.3 ppb in August 1998. The highest concentration detected to date in Municipal Well 3 was 91.4 ppb in April 2000 (Reference 21, Table 1 [page 21-29, 21-30]). Municipal Well 2 has had elevated levels of PCE at concentrations exceeding the Maximum Contaminant Level (MCL) on two occasions and Municipal Well 5 has had elevated levels of PCE on 18 occasions between October 1989 and May 2000, with four of the detections at

concentrations exceeding the MCL (Reference 21, Table 1 [pages 21-29, 21-39]). The MCL for PCE is 5 ppb (Reference 2, page 2-11).

On December 27, 1998, the City began pumping Well 3 to the Ravenswood wastewater treatment plant in an effort to protect the remaining wells from contamination (Reference 21, page 5; Reference 9, page 9-08, Reference 24, page 24-02; Reference 29, page 29-01). Well 3 was pumped continuously at a rate of 100 gallons per minute (gpm), which is the maximum rate that the sewer system can process (Reference 9, page 9-08). The City faces a potential for a water shortage as three of its five wells have historically shown PCE contamination (Reference 27, page 1; Reference 9, page 9-08). PCE contamination in Well 5 increased from 10.7 ppb in January 1999 to 21.7 ppb in November 1999. In November 1999, PCE was also detected at a concentration of 5.6 ppb in the finished water (blended water from all the wells) (Reference 21, Table 1 [pages 21-29, 21-30). After Well 3 began pumping continuously to the wastewater plant in December 1998, contamination in Well 2 and Well 5 diminished. PCE has not been detected in Well 2 since the August 1998 sampling event (Reference 21, Table 1 [pages 21-29, 21-30]; Reference 37, Table 5 [page 37-18]; Reference 38, page 1). PCE concentrations in Well 5 began to decrease from 10.7 ppb detected in January 1999 to less than 1 ppb detected in the six sampling events conducted from February to April 2000 and a detection of 2 ppb in May 2000 (Reference 21, Table 1 [pages 21-29, 21-30]). The West Virginia Department of Environmental Protection (WVDEP) sampled Municipal Wells 2, 3, and 5 in July 2001. Analytical results indicated that PCE was not detected in Wells 2 and 5, and Well 3 had a concentration of 22.9 ppb (Reference 37, Table 5 [page 37-18]). WVDEP sampled the municipal wells again in March/April 2002. Analytical results indicated non-detect in Municipal Wells 2 and 5, and 33 : g/L in Municipal Well 3 (Reference 39, pages 39-133, 39-134, 39-136, 39-137, 39-142, 39-143, 39-19, 39-81; Reference 22, page 22-03). Since May 2000, however, the water from Wells 3 and 5 has been pumped into a chamber using an air stripper to remove PCE and this treated water is blended with water from Wells 1, 2, and 4 (Reference 32, page 32-01; and Reference 38, page 38-01). In May 2000, the City of Ravenswood began analyzing water influent to, and effluent from the air stripper unit. PCE results for influent water in the ten sampling events conducted from May to November 2000 ranged from 19 to 47.6 ppb. Results for the effluent from the air stripper following treatment during the same time frame ranged from 2.3 to 4.2 ppb (Reference 21, Table 1 [pages 21-29, 21-30]). Since the installation of the air stripper unit in June 2000, the finished water blend meets the MCL requirement for PCE concentration (Reference 21, Table 1 [pages 21-29, 21-30]; Reference 27, page 1; Reference 38, page 1).

The following table provides a list of sample numbers used during the EPA and WVDEP sampling events as specified in the respective references:

Sample Numbers Corresponding to Municipal and Monitoring Wells

Well	Reference 9	Reference 21	Reference 37	Reference 39
Municipal Well 1	W-1 (CWS35)	PW-1	NS	PW1 (C4022)
Municipal Well 2	W-2 (CWW25)	PW-2	PW-2	PW2 (C4024)
Municipal Well 3	W-3 (CWS38)	PW-3	PW-3	PW3 (C4026)
Municipal Well 4	W-4 (CWS36)	PW-4	NS	PW4 (C4028)
Municipal Well 5	W-5 (CWS39)	PW-5	PW-5	PW5 (C4030)
Monitoring Well 1	G-1 (CWW24)	MW-1	MW-1	EPA 1 (C4000)
Monitoring Well 2	G-2 (CWW23)	MW-2	MW-2	EPA 2 (C4002)
Monitoring Well 3	G-3 (CWW22)	MW-3	MW-3	EPA 3 (C4004)
Monitoring Well 4	G-4 (CWW21)	NS	MW-4	EPA 4 (C4006)
Monitoring Well 5S	NS	NS	MW-5S	DEP 5S (C4008)
Monitoring Well 5D	NS	NS	MW-5D	DEP 5D (C4010)
Monitoring Well 6	NS	NS	MW-6	DEP 6 (C4012)
Monitoring Well 7	NS	NS	MW-7	DEP 7 (C4014)
Monitoring Well 8	NS	NS	MW-8	DEP 8 (C4016)
Monitoring Well 9	NS	NS	MW-9	DEP 9 (C4018)
Monitoring Well 10	NS	NS	MW-10	DEP 10 (C4020)

Key: NS - Not sampled.
(#####) - CLP No.

The precise boundaries of the Ravenswood PCE Ground Water Plume site and the extent of contamination have not been fully delineated. However, a ground water investigation conducted by WVDEP from the summer of 2000 through 2001 determined that the ground water plume extends from the area of Municipal Well 3 on Virginia Street in a southward direction for approximately 1,400 feet to Broadway Street (Reference 37, page 37-11). The plume width is estimated to be approximately 400 feet wide in the upper portion of the water bearing zone and 100 feet in the lower portion of the water bearing zone (Reference 37, page 37-11). The size of the plume was estimated based on analytical results from the five municipal wells, four

monitoring wells installed by EPA, seven monitoring wells installed by WVDEP, and ground water samples collected from GeoProbe™ borings during the State investigation (Reference 37, pages 37-08, 37-09). The WVDEP investigation also determined that the ground water flow in the area south and west of the site was generally in a northward direction toward the municipal well field. The aquifer beneath Ravenswood is an unconfined alluvial aquifer located in a floodplain composed of unconsolidated glacial outwash sediments of Pleistocene Age (Reference 9, page 11). The aquifer has a transmissivity estimated to be between 6,000 and 35,000 square feet per day (Reference 10, page 10-02). Groundwater in alluvium along the Ohio River is typically recharged from the infiltration of precipitation, water from the Ohio River, and transfer from adjacent bedrock aquifers (Reference 9, page 9-11). The alluvial aquifer is hydraulically connected to the Ohio River, therefore, the water table elevation fluctuates with the level of the river. Based on topographic relief, river location, and river flow directions, ground water flow direction would be assumed to be to the south and west (Reference 21, page 21-12). The northerly flow direction in the area south and west of the site is likely due to drawdown from the pumping from the municipal wells, creating a cone of depression in the wellfield (Reference 21, page 21-12; Reference 37, pages 37-08 to 37-09).

For HRS purposes, the dimension of the Ravenswood ground water plume is based on available samples collected from the municipal wells and monitoring wells that meet the criteria for an observed release. The area lying between these sampling points is considered part of the plume.

SOURCE DESCRIPTION

2.2 Source Characterization

2.2.1 Source Identification

Number of the source: 1

HRS Source Type: Other

Source 1 has been identified as a ground water plume. The ground water plume can be considered a source in the case of a plume site with no identified sources (Reference 1, Section 1.1, page 51587).

Name and description of the source: Ravenswood Ground Water Plume

Based on the analytical results from the August 1999 SI sampling event, two of the five municipal drinking water wells are contaminated with PCE. Ground water samples collected in the monitoring and municipal wells during the August 1999 SI sampling event contained PCE at greater than three times background concentrations (Reference 9, page 9-09). PCE was detected at a concentration of 30 : g/L in sample W-3 (from Municipal Well 3), and at 14 : g/L in sample W-5 (from Municipal Well 5) (Reference 9, page 9-09). PCE was not detected in the background samples (see Section 3.1.1).

Additionally, analytical results for ground water samples collected from municipal wells and monitoring wells in the WVDEP investigations conducted in 2001 and 2002, indicated PCE and cis-1,2-dichloroethene at elevated concentrations (Reference 37, [Table 5, page 37-18]; Reference 39, pages 39-06 through 39-23). In the 2001 investigation, PCE was detected in the following samples: 22.9 : g/L in PW-3 (from Municipal Well 3); 8.0 : g/L in MW-4 (from Monitoring Well 4); 324 : g/L in MW-5S (from Monitoring Well 5S); 7.8 : g/L in MW-5D (from Monitoring Well 5D); 21.3 in MW-6 (from Monitoring Well 6); 19.5 : g/L in MW-7 (Monitoring Well 7); 2.6 : g/L in MW-8 (Monitoring Well 8); and 1.2 : g/L in MW-10 (from Monitoring Well 10) (Reference 37, Table 5 [page 37-18]). (NOTE: No data validation was completed for this data. Data are provided for informational purposes only and do not affect the site score.). In the WVDEP sampling investigation conducted from March 27 to April 1, 2002, PCE was detected in the following samples: 33 : g/L in PW3 (from Municipal Well 3); 430 : g/L in DEP 5D (from Monitoring Well 5D); 130 : g/L in DEP 7 (from Monitoring Well 7); and 35 : g/L in DEP 8 (from Monitoring Well 8) (Reference 39, pages 39-06 through 39-23).

Location of the source (See Figure 2): Source No. 1

Spatial and analytical relationships between sampling locations indicate the presence of a plume of PCE contamination in the ground water extending from the area of Municipal Well 3 on Virginia Street in a southward direction for approximately 1,400 feet to Broadway Street. The plume width is estimated to be approximately 400 feet wide in the upper portion of the water bearing zone and 100 feet in the lower portion of the water bearing zone (Reference 37, page 37-11). The size of the plume was estimated based on analytical results from the five municipal wells, four monitoring wells installed by EPA, seven monitoring wells installed by WVDEP, and ground water samples collected from GeoProbe™ borings during the State investigation (Reference 37, pages 37-08, 37-09). The WVDEP investigation also determined that the ground water flow in the area to the south and west of the site was generally in a northward direction toward the Municipal Well field. The northerly flow direction is likely a localized condition due to the pumping from the municipal wells (Reference 37, page 37-09).

2.2.2 Hazardous Substances Associated with the Source

Hazardous Substance	Field/Lab Sample ID[1] (Concentration)	SQL (:g/L)	Ref(s)
Tetrachloroethene (PCE)	W-3/CWS38 (30 :g/L) W-5/CWS39 (14 :g/L)	1 0.5	(9, pages 9-09, 9-16, 9-40, 9-41)

Notes: Sample Nos. W-3/CWS38 and W-5/CWS39 were collected during the Site Inspection sampling event on August 25, 1999 and were analyzed using Contract Laboratory program (CLP) Statement of Work (SOW) OLC02.1 (Reference 9, pages 9-10, 9-31, 9-40).

See Section 3.1.1 for additional sample data indicating the presence of hazardous substances.

Key: :g/L - Micrograms per liter
SQL - Sample quantitation limit. The SQL is the quantity of a substance that can be reasonably quantified given the limits for detection for the method of analysis and sample characteristics that may affect quantitation (Reference 1, page 51586). The SQL is derived from the CLP Contract Required Quantitation Limit (CRQL) by adjusting the CRQL value to account for sample dilutions and for analysis of a sample volume which differs from the volume for aqueous samples specified in the CLP Statement of Work (SOW) OLC03.2 (Reference 4, pages 4-09, 4-13, 4-11, 4-12; Reference 41, page 41-01). The SQLs used in this table are equivalent to the Adjusted CRQLs in the CLP SOW for OLC03.2 (Reference 4, page 4-13). OLC03.2 has replaced OLC02.1 for analysis of low concentration organics in water, however the CRQL for tetrachlorethene did not change. (Reference 40, pages 40-01 to 40-03). Therefore, the calculation for the SQL would be the same for OLC02.1 and OLC03.2 (Reference 4, pages 4-13, 4-09, 4-11; Reference 41, page 41-01).

Hazardous Substances Associated with the Source:

Tetrachloroethene (PCE)

2.2.3 Containment

Based on the analytical results from the August 1999 SI sampling event, two of the five municipal drinking water wells are contaminated with PCE (Reference 9, page 9-09 and Appendix 1 [pages 9-15 to 9-26]). Additional analytical data obtained since the SI have substantiated the SI results and further defined the extent of the plume. The additional data were obtained from the following sampling events: five sampling events conducted by the EPA Removal Branch between January 31, 2000 and May 18, 2000; WVDEP Investigation sampling conducted between July 23, 2001 and October 25, 2001; and WVDEP sampling conducted from March 27, 2002 to April 1, 2002 (Reference 16, Reference 17, Reference 18, Reference 19, Reference 20, Reference 37, and Reference 39). Source 1 is assigned a ground water containment factor value of 10 based on evidence of an observed release to ground water (Reference 1, Table 3-2, page 51596). Targets were subject to Level I concentrations (See Section 3.2.2 of this documentation record).

Containment Value: 10
Reference 1, Table 3-2, page 51596

2.4.2 Hazardous Waste Quantity

2.4.2.1.1 Hazardous Constituent Quantity

Insufficient information is available to evaluate hazardous constituent quantity.

2.4.2.1.2 Hazardous Waste stream Quantity

Insufficient information is available to evaluate hazardous waste stream quantity.

2.4.2.1.3 Volume

The full extent of the PCE plume has not been determined at this stage in the assessment process due to insufficient data available to allow for an accurate volume calculation, therefore, a value of >0 has been assigned (Reference 1, page 51591).

Dimension of source (yd^3): >0 yd^3

References(s):1, Section 2.4.2.1.3, Table 2-5

Volume Assigned Value: >0

2.4.2.1.4 Area

The volume/area was not adequately determined, therefore, a value of >0 has been assigned (Reference 1, page 51591).

2.4.2.1.5 Source Hazardous Waste Quantity Value

From above, the highest of the values assigned to Source 1 is >0. Thus, this value has been assigned the source hazardous waste quantity value for Source 1.

Source Hazardous Waste Quantity Value: >0
(Reference 1, Section 2.4.2.1.5)

2.4.2.2 Hazardous Waste Quantity Factor Value

According to the HRS Rule (Reference 1), if the hazardous constituent quantity is not adequately determined for one or more sources, (or one or more portions of sources remaining after a removal action) assign a factor value as follows, "[I]f any target from the migration pathway is subject to Level I or Level II concentrations (see Section 2.5) assign either the value from Table 2-6 or a value of 100, whichever is greater, as the hazardous waste quantity factor value for that pathway." Based on this, a hazardous waste quantity factor value of 100 has been assigned for Source 1 for the ground water migration pathway.

Hazardous Waste Quantity Factor Value: 100
(Ref. 1, Section 2.4.2.2)

SITE SUMMARY OF SOURCE DESCRIPTIONS

Source No.	Source Hazardous Waste Quantity Value	Containment			
		Ground-Water	Surface Water	Air Gas	Air Particulate
1	>0	10	NS	NS	NS

Note: NS - Not Scored
Reference 1, Section 2.4.2.1.5

Other Potential Sources

During the development of the HRS documentation record for the Ravenswood PCE Ground Water Plume site, EPA identified the following potential sources:

1. Three former dry cleaning facilities;
2. Former trash/waste dump;
3. Metal scrap heap;
4. Ravenswood Municipal building; and
5. Former Hospital

These potential sources were investigated by EPA and WVDEP in an effort to identify the source of the ground water contamination plume. The investigations did not obtain sufficient data to substantiate that any of these potential sources contributed to the PCE contamination. The following discussion is included to document that the investigation to determine the source of the contamination involved a level of effort equivalent to an expanded SI investigation.

To address contamination issues and identify sources of contamination, the EPA Emergency Response Team (ERT) performed an environmental investigation with sampling events in March and May, 1999 (Reference 21, page 21-13). The ERT tasked the Response Engineering and Analytical Contract (REAC) contractor to develop and implement a soil gas survey to locate potential sources of PCE contamination. The survey encompassed an area of about 25 city blocks (100 acres) and included the wellfield and the area of the three defunct dry cleaners to the south and west of the wellfield (Reference 21, page 21-13; Reference 11, pages 11-01 and 11-02). The survey also encompassed the location of the former trash/waste dump, metal scrap heap, Ravenswood municipal building, and the former hospital (Reference 21, pages 21-10, 21-11, 21-35). REAC conducted the first soil gas survey in March 1999. On March 4, 1999, only three samples contained PCE above the quantitative limit of 10 ppb; the highest concentration recorded was at 30 ppb. On March 5, 1999, REAC collected soil gas samples from 14 locations at six feet below ground surface. PCE was detected above the quantitative limit in one sample at 61 ppb (Reference 11, page 11-02).

In May 1999, the ERT mobilized to the site to continue the survey, which encompassed an area of about 25 city blocks (100 acres) and included the wellfield. PCE was only detected at three locations near Municipal Well 3. The highest concentration observed was 276 ppb. From this investigation, EPA determined that these investigations were inconclusive and that further investigations were needed to identify potential sources of PCE. EPA decided to install monitoring wells in the vicinity of the wellfield to further investigate the source of contamination (Reference 21, page 21-14; Reference12, pages 12-01, 12-02; Reference 30, page 30-02; and Reference 31, pages 31-01 through 31-04).

Based on area geology, the ground water flow direction is expected to be to the south. However, based on ground water elevation data between the municipal well field and the Ohio River obtained in the State investigation, it was determined that ground water flow direction is actually

to the north in the area to the south and west, towards the municipal well field (Reference 37, page 37-09). This flow direction, which is opposite the previously assumed natural gradient, is most likely due to induced flow from the municipal wells (Reference 21, page 21-21; Reference 37, page 37-09). All of the potential sources identified above, except for the municipal building, are located south, i.e., upgradient, of the municipal well field. The aquifer beneath Ravenswood is unconfined and highly transmissive. Transmissivity has been estimated to be between 6,000 and 35,000 square feet per day (Reference 10, page 10-05, Reference 21, page 21-12). Based on the soil gas survey conducted by REAC, and soil sampling conducted by WVDEP to date, insufficient data are available to positively identify the source of the plume (References 10, page 10-05; Reference 11, page 11-02; Reference 12, page 12-02; Reference 21, Table 2 [page 21-31]); Reference 37, Table 4 [page 37-17]).

3.0 Ground Water Migration Pathway

3.0.1 General considerations

Hydrogeological Setting

Jackson County lies in the Appalachian Plateaus Physiographic Province. The region is characterized by a mature topography where the plateau surface is dissected by a network of streams representing a dendritic drainage pattern. Rocks within the area consist of flat lying shales and claystones (redbeds), channel sandstones, lacustrine limestones and occasional coal beds of the Washington, Waynesburg, and Greene Formations (Reference 8, West Sheet; Reference 9, page 9-11).

The site is located approximately 1,700 feet northeast of the Ohio River on the Ravenswood Bottom and the river flows in a southeasterly direction in this vicinity. The floodplain is composed of unconsolidated glacial outwash sediments of Pleistocene age. Two prominent terraces are visible on the Ravenswood Bottom. The lower terrace lies 30 to 40 feet above normal pool elevation of the Ohio River, the upper terrace lies 60 to 70 feet above normal pool elevations (Reference 8, West Sheet; Reference 9, page 9-11).

Sediments in the floodplain at Ravenswood are composed primarily of sand with some silt and fine gravel mixed in. The sediments commonly fine upward becoming clay-rich near the surface. Depth of the floodplain deposits within the Ravenswood well field is between 90 and 100 feet (Reference 10, pages 10-07 through 10-15; Reference 9, page 9-11). These floodplain deposits make up the Quaternary Alluvium Aquifer. Depth to the water table is approximately 60 feet bgs (Reference 37, Table 8 [page 37-21]; Reference 15, pages 15-8 to 15-11, 15-15). In the vicinity of the Ravenswood municipal well field, the Quaternary Aquifer is unconfined, consisting of alluvial sands with minor, non-contiguous clay layers from the surface down to bedrock at approximately 90 feet bgs. The aquifer is hydraulically connected with the Ohio River to the southwest and Sandy Creek to the southeast (Reference 9, page 9-11; Reference 21, page 21-12; Reference 37, page 37-11). All five municipal and ten of the eleven monitoring wells are drilled to bedrock and are screened in the Quaternary Aquifer. Monitoring Well 5S is screened in the upper portion of the Quaternary Aquifer. Municipal Wells 4 and 5 are screened over 10-foot intervals (the screen intervals in Municipal Wells 1, 2, and 3 are unknown) and the four EPA-installed monitoring wells (Monitoring Wells 1, 2, 3, and 4) are screened over 20-foot intervals upward from their bases (Reference 15, pages 8 to 11, 15; Reference 37, pages 37-24 to 37-30; Reference 10, Appendix A [pages 10-07 to 10-15]). WVDEP installed Monitoring Wells 5D, 5S, 6, 7, 8, 9, and 10. Monitoring wells MW 5D, MW 5S, and MW 6 were each screened over a 10-foot interval. Monitoring wells MW 7, MW 8, MW 9, and MW 10 were each screened over a 20-foot interval (Reference 37, pages 37-24 to 37-30).

The aquifer beneath Ravenswood is an unconfined alluvial aquifer located in a floodplain composed of unconsolidated glacial outwash sediments of Pleistocene Age (Reference 9, page 9-11). The aquifer has a transmissivity estimated to be between 6,000 and 35,000 square feet per

day (Reference 9, page 9-11; Reference 10, page 10-02; Reference 21, page 21-12). Groundwater in alluvium along the Ohio River is typically recharged from the infiltration of precipitation, water from the Ohio River, and transfer from adjacent bedrock aquifers located landward from the river (Reference 9, page 9-11). The alluvial aquifer is hydraulically connected to the Ohio River, therefore, the water table elevation fluctuates with the level of the river (Reference 21, page 21-12). The ground water elevation is approximately 556 to 560 feet above mean sea level (amsl) (Reference 21, page 21-12; Reference 37, pages 37-24 to 37-30). Based on topographic relief, river location, and river flow directions, ground water flow direction would be assumed to be to the south and west (Reference 9, page 9-11; Reference 21, page 21-12). The WVDEP used static water data from the eleven monitoring wells located in the area south and west of the site, measured during the investigation conducted from July 2001 to October 2001, along with spatial coordinates to manually map and estimate equipotential contours, flow direction, and the pumping well capture zone (Reference 37, pages 37-08, 37-09, 37-24 to 37-30, 37-20 [Table 7], and 37-22 to 37-23 [Table 9]). Based on this water elevation data, it was determined that in the area south and west of the site, ground water flow direction is actually to the northeast from the Ohio River and Sandy Creek towards the municipal well field (Reference 37, pages 37-09, 37-11). The northerly flow direction is likely a localized condition caused by a draw down from the pumping from the municipal wells, creating a cone of depression in the wellfield (Reference 21, page 21-12; Reference 37, pages 37-08 to 37-09).

3.1 Likelihood of release

3.1.1 Observed release

Chemical Analysis

An analysis of ground water samples from the Quaternary Alluvium aquifer indicates that the concentration of hazardous substance(s) has increased significantly above the background concentration for the site (Reference 1, Section 2.3). Municipal Wells 1 (PW1 on Figure 2) and 4 (PW4 on Figure 2) have been designated as the background wells for the observed release. Each of the background wells are drilled to bedrock which is approximately 90 to 95 feet below ground surface (Reference 15, pages 15-08 to 15-11, 15-14, 15-15).

Ground water samples collected in Municipal Wells 3 and 5 (PW3 and PW5, respectively, on Figure 2) during the August 1999 SI sampling event contained PCE at greater than three times background concentrations (Reference 9, page 9-09, Appendix 1 [pages 9-15 to 9-26]). PCE was detected at a concentration of 30 ：g/L in grab sample W-3 (from Municipal Well 3), and at 14 ：g/L in grab sample W-5 (from Municipal Well 5) (Reference 9, page 9-09, Appendix 1 [pages 9-15 to 9-26], pages 9-40, 9-41; Reference 13, page 13-06). From March 1999 through May 2000, sampling conducted by the City of Ravenswood indicated concentrations ranging from 23.7 to 91.4 ppb for Municipal Well 3 and concentrations ranging from non-detect to 21.7 ppb for Municipal Well 5 (Reference 21, Table 1 [pages 21-29, 21-30]). Ravenswood Municipal well sampling data obtained by subsequent investigations conducted by EPA indicate concentrations of PCE comparable to concentrations found during the August 1999 SI sampling event and with data obtained by the City of Ravenswood. The analytical reports for the EPA sampling, dating from February through June 2000, indicated high concentrations of PCE within Well 3 at the site. These concentrations range from 39.9 to 73.9 ppb (Reference 16, pages 16-03, 16-07; Reference 17, pages 17-03, 17-07; Reference 18, pages 18-03, 18-07; Reference 19, pages 19-05, 19-07; and Reference 20, pages 20-03, 20-07). Results of EPA's sampling of Wells 3 and 5 are summarized in the table below.

Analytical Results for U.S. EPA Sampling – Municipal Wells 3 and 5

Sampling Date	Sample ID/Well No.	PCE Concentration (:g/L)	AQL (:g/L)	Reference(s)
Municipal Well No. 3				
31 January, 2000	00020103/Well 3	39.9 C	5	(Reference 16, pages 16-02, 16-03, 16-05, 16-07, 16- 12, 16-13, 16-14)
23 February, 2000	00022408/Well 3	43.8 C	5	(Reference 17, pages 17-02, 17-03, 17-05, 17-07, 17-11, 17-12, 17-15)
21 March, 2000	00032209/Well 3	47.7 C	5	(Reference 18, pages 18-02, 18-03, 18-04, 18-06, 18-07, 18-10, 18-13, 18-14)
18 April, 2000	00041903/Well 3	50.3 C	5	(Reference 19, pages 19-04, 19-05, 19-06, 19-07, 19-11, 19-12, 19-14)
18 May, 2000	00051903/Well 3	73.9 C	5	(Reference 20, pages 20-02, 20-03, 20-04, 20-07, 20-11, 20-12)
Municipal Well No. 5				
31 January, 2000	00020105/Well 5	1.6	1	(Reference 16, pages 16-02, 16-03, 16-07, 16-13, 16-14)
23 February, 2000	00022410/Well 5	ND	1	(Reference 17, pages 17-02, 17-03, 17-05, 17-07, 17-11, 17-15)
21 March, 2000	00032211/Well 5	ND	1	(Reference 18, pages 18-02, 18-03, 18-04, 18-06, 18-10, 18-13)
18 April, 2000	00041905/Well 5	ND	1	(Reference 19, pages 19-04, 19-05, 19-07, 19-11, 19-14)
18 May, 2000	00051905/Well 5	2	1	(Reference 20, pages 20-02, 20-03, 20-07, 20-11, 20-12)

Key: : g/L - micrograms per liter
AQL - Actual Quantitation Limit. The AQL is calculated by multiplying the Nominal Quantitation Limit (NQL) times the NQL factor listed on the sample result page in the data packages, unless superceded by other information provided in the report. The NQLs are listed in the Office of Analytical Services and Quality Assurance Volatile Organic Analysis Nominal Quantitation Limits (NQL) Table which is provided in references 16 through 20. The NQL factors are provided on the sample results pages in references 16 through 20. The NQL factor is an overall correction factor applied to the methods NQL to account for sample dilutions and for analysis of a sample volume which differs from the ideal volume for aqueous samples. The NQL factors for samples from Municipal Well 3 were incorrect on the sample result pages in References 16, 17, 18, 19, and 20, however the correct NQL factor is provided in the Laboratory narratives included in each of the references. See table above sample specific references.
C - The result was obtained from sample dilution resulting in the compound concentration within the quantitation range (References 16, pages 16-05, 16-12; Reference 17, pages 17-04, 17-12; Reference 18, pages 18-04,18-14; Reference 19, pages 19-06, 19-12; Reference 20, pages 20-04, 20-12)

Information contained within the August 1999 SI indicated that PCE was also detected at 8.3 parts per billion (ppb) in Municipal Well 2 (PW2 on Figure 2) during a 1998 sampling event (Reference 9, pages 9-08, 9-14, Reference 21, Table 1 [pages 21-29, 21-30]). However, data obtained during the SI sampling event in August 1999 indicated a non-detect for PCE in Municipal Well 2 (Reference 9, Appendix 1, [pages 9-15 to 9-26], page 9-46).

Additionally, analytical results for ground water samples collected from municipal wells and monitoring wells in the WVDEP investigation conducted in 2001 and 2002, indicated PCE at elevated concentrations (Reference 37, Table 5 [page 37-18]; Reference 39, pages 39-06 through 39-23). In the 2001 sampling investigation, PCE was also detected in the municipal wells and monitoring wells at elevated concentrations as follows: 22.9 : g/L in PW-3 (from Municipal Well 3); 8.0 : g/L in MW-4 (from Monitoring Well 4); 324 : g/L in MW-5S (from Monitoring Well 5S); 7.8 : g/L in MW-5D (from Monitoring Well 5D); 21.3 in MW-6 (from Monitoring Well 6); 19.5 : g/L in MW-7 (Monitoring Well 7); 2.6 : g/L in MW-8 (Monitoring Well 8); and 1.2 : g/L in MW-10 (from Monitoring Well 10) (Reference 37, Table 5 [page 37-18]). See table below for complete analytical data for monitoring and municipal wells sampled during the event. (NOTE: No data validation was completed for this data and laboratory documentation was not available for data presented in Reference 37 to allow for validation to be conducted. Data are provided for informational purposes only and do not affect the site score.).

Analytical Results for WVDEP Sampling Conducted in 2001 – Municipal and Monitoring Wells (***NOTE***: *No data validation was completed for this data. The data are presented for informational purposes only and do not affect the site score*.)

Sampling Date	Sample ID/Well No.	PCE Concentration (µg/L)	EQL (µg/L)	Reference(s)
23 July, 2001	PW-2/ Municipal Well 2	ND	1	(Ref. 37, Table 5 [page 37-18])
23 July, 2001	PW-3/ Municipal Well 3	22.9	1	(Ref. 37, Table 5 [page 37-18]
23 July, 2001	PW-5/ Municipal Well 5	ND	1	(Ref. 37, Table 5 [page 37-18])
25 October, 2001	MW-1/Monitoring Well 1	ND	1	(Ref. 37, Table 5 [page 37-18])
25 October, 2001	MW-2/ Monitoring Well 2	ND	1	(Ref. 37, Table 5 [page 37-18])
25 October, 2001	MW-3/Monitoring Well 3	ND	1	(Ref. 37, Table 5 [page 37-18])
25 October, 2001	MW-4/Monitoring Well 4	8	1	(Ref. 37, Table 5 [page 37-18])
8 October, 2001	MW-5S/Monitoring Well 5S	324	1	(Ref. 37, Table 5 [page 37-18])
8 October, 2001	MW-5D/Monitoring Well 5D	7.8	1	(Ref. 37, Table 5 [page 37-18])
8 October, 2001	MW-6/Monitoring Well 6	21.3	1	(Ref. 37, Table 5 [page 37-18])
8 October, 2001	MW-7/Monitoring Well 7	19.5	1	(Ref. 37, Table 5 [page 37-18])
8 October, 2001	MW-8/Monitoring Well 8	2.6	1	(Ref. 37, Table 5 [page 37-18])
8 October, 2001	MW-9/Monitoring Well 9	ND	1	(Ref. 37, Table 5 [page 37-18])
8 October, 2001	MW-10/Monitoring Well 10	1.2	1	(Ref. 37, Table 5 [page 37-18])

Key: : g/L - micrograms per liter
EQL - Estimated Quantitation Limit (Reference 42, page 42-02; Reference 43, page 43-01; Reference 37, pages 37-31 to 37-62).

In the WVDEP sampling investigation conducted from March 27 to April 1, 2002, PCE was detected in the following samples at concentrations exceeding three times background concentration: 33 : g/L in PW3 (from Municipal Well 3); 430 : g/L in DEP 5D (from Monitoring Well 5D); 130 : g/L in DEP 7 (from Monitoring Well 7); and 35 : g/L in DEP 8 (from Monitoring Well 8) (Reference 39, pages 39-06 through 39-23). These analytical results were obtained through the Contract Laboratory Program (CLP) and the data have been validated. See table below for complete analytical data for monitoring and municipal wells sampled during the event.

Analytical Results for WVDEP Sampling Conducted in 2002 – Municipal and Monitoring Wells *(**NOTE:** Sample analysis was completed at a CLP Laboratory. Data were validated by ESAT.)*

Sampling Date	Sample ID/Well No.	PCE Concentration (: g/L)	SQL (: g/L)	Reference(s)
29 March, 2002	EPA 1/C4000/ Monitoring Well 1	ND	10	Ref. 39, pages 39-11, 39-98
29 March, 2002	EPA 2/C4002/ Monitoring Well 2	ND	10	Ref. 39, pages 39-11; 39-101
1 April, 2002	EPA 3/C4004/ Monitoring Well 3	ND	10	Ref. 39, pages 39-11; 39-104
29 March, 2002	EPA 4/C4006/ Monitoring Well 4	ND	10	Ref. 39, pages 39-11; 39-107
27 March, 2002	DEP 5S/C4008/ Monitoring Well 5S	ND	10	Ref. 39, pages 39-11; 39-110
27 March, 2002	DEP 5D/C4010/ Monitoring Well 5D	430	50	Ref. 39, pages 39-15; 39-116
28 March, 2002	DEP 6/C4012/ Monitoring Well 6	ND	10	Ref. 39, pages 39-15; 39-119
1 April, 2002	DEP 7/C4014/ Monitoring Well 7	130	10	Ref. 39, pages 39-15; 39-122
1 April, 2002	DEP 8/C4016/ Monitoring Well 8	35	10	Ref. 39, pages 39-15; 39-125
1 April, 2002	DEP 9/C4018/ Monitoring Well 9	ND	10	Ref. 39, pages 39-15; 39-128

Sampling Date	Sample ID/Well No.	PCE Concentration (:g/L)	SQL (:g/L)	Reference(s)
1 April, 2002	DEP 10/C4020/ Monitoring Well 10	ND	10	Ref. 39, pages 39-27; 39-261
28 March, 2002	PW1/C4022/ Municipal Well 1	ND	10	Ref. 39, pages 39-19; 39-131
28 March, 2002	PW1A/C4032/ Municipal Well 1 (duplicate sample)	ND	10	Ref. 39, pages 39-23; 39-146
27 March, 2002	PW2/C4024/ Municipal Well 2	ND	10	Ref. 39, pages 39-19; 39-134
27 March, 2002	PW3/C4026/ Municipal Well 3	33	10	Ref. 39, pages 39-19; 39-137
27 March, 2002	PW4/C4028/ Municipal Well 4	ND	10	Ref. 39, pages 39-19; 39-140
27 March, 2002	PW5/C4030/ Municipal Well 5	ND	10	Ref. 39, pages 39-19; 39-143

Key: :g/L - micrograms per liter

SQL - Sample Quantitation Limit. The SQL is the quantity of a substance that can be reasonably quantified given the limits for detection for the method of analysis and sample characteristics that may affect quantitation (Reference 1, page 51586). The SQL is derived from the CLP Contract Required Quantitation Limit (CRQL) by adjusting the CRQL value to account for sample dilutions and for analysis of a sample volume which differs from the volume for aqueous samples specified in the CLP SOW OLM04.2 (Reference 44, pages 44-05, 44-10, 44-07, 44-08; Reference 41, page 41-01). The SQLs used in this table are equivalent to the Adjusted CRQLs in the CLP SOW for OLM04.2 (Reference 44, page 44-10; Reference 41, page 41-01).

Background Samples:

Municipal Well Nos. 1 and 4 are considered to be representative of background conditions. The wells are completed to approximately the same depth as the wells from which the release samples were collected, and they are screened at approximately the same depth intervals (Reference 15, pages 15-8 to 15-11, 15-15). Background and release samples were collected from municipal wells during the SI directly from the pump after purging for 15 minutes. Monitoring wells were sampled using a submersible pump and dedicated Teflon tubing after purging three well volumes (Reference 13, page 13-05). The samples were analyzed using CLP Statement of work (SOW) OLC02.1, Low Concentration Organics (Reference 9, page 9-31). During the WVDEP sampling event conducted in March-April, 2002, monitoring well samples were collected using Low Flow (Minimal Drawdown) Ground-Water Sampling Procedures (EPA/540/S-95/504) and municipal well samples were collected from the pump directly into the sample containers (Reference 7, pages 7-10, 7-11, 7-12; Reference 22, pages 22-01 to 22-26). The samples were analyzed using CLP SOW OLM04.2 Volatile Organics, which has higher CRQLs than OLC02.1 (Reference 39, page 39-03, 39-11 to 39-30; pages 22-01 to 22-26). All samples were unfiltered (Reference 7, pages 7-11, 7-12; Reference 13, page 13-05, 13-06).

Based on topographic relief, river location, and river flow directions, ground water flow direction would be assumed to be towards the Ohio River to the south and west (Reference 9, page 9-11; Reference 21, page 21-12). The WVDEP used static water data measured in the eleven monitoring wells during the investigation conducted from July 2001 to October 2001, along with spatial coordinates to manually map and estimate equipotential contours, flow direction, and the pumping well capture zone (Reference 37, pages 37-08, 37-09, 37-24 to 37-30, Table 7 [page 37-20], and Table 9 [pages 37-22, 37-23]). Based on this water elevation data, it was determined that the ground water flow direction is actually to the northeast from the Ohio River and Sandy Creek towards the municipal well field rather than toward the river (Reference 37, page 37-09, 37-11). The northerly and easterly flow direction is likely a localized condition caused by a drawdown from the pumping from the municipal wells, creating a cone of depression in the wellfield (Reference 21, page 21-12; Reference 37, pages 37-08 to 37-09). Though the presumed ground water flow direction to the northeast is toward the background wells, the release sample wells are located between the observed plume and the background wells. It is apparent that Municipal Well 3 is intercepting the PCE plume and preventing the background wells from being impacted, as evidenced by no detections of PCE in the background wells. Therefore Municipal Well Nos. 1 and 4 are considered to be representative of background ground water conditions.

Background Samples:

Sample ID (Field/Lab)	Sample Location	Screened Interval (Ft msl)	Sampling Date	Reference(s)
Background Samples for SI Sampling Conducted in August 1999				
W-1/CWS35	Municipal Well 1	Unknown, (well depth 522.84' msl)	August 24, 1999	Ref. 9, p. 9-10; Ref. 15, p.15-08
W-4/CWS36	Municipal Well 4	533.84 to 523.84	August 24, 1999	Ref. 9, p. 9-10; Ref. 15, p. 15-11
W-6/CWS37	Municipal Well 4 Duplicate of W-4	533.84 to 523.84	August 24, 1999	Ref. 9, p. 9-10; Ref. 15, p. 15-11
Background Samples for WVDEP Sampling Conducted in March-April 2002				
PW 1/C4022	Municipal Well 1	Unknown, (well depth 522.84' msl)	March 28, 2002	Ref. 9, p. 9-10; Ref. 15, p.15-08; Ref. 39, p. 39-19
PW 1A /C4032	Municipal Well 1 Duplicate of PW 1	Unknown, (well depth 522.84' msl)	March 28, 2002	Ref. 9, p. 9-10; Ref. 15, p.15-08; Ref. 39, p. 39-23
PW 4/C4028	Municipal Well 4	533.84 to 523.84	March 27, 2002	Ref. 9, p. 9-10; Ref. 15, p. 15-11; Ref. 39, p. 39-19

Release Samples: (See Figure 2, Sample Location Map)

Sample ID (Field/Lab)	Sample Location	Screened Interval (Ft msl)	Sampling Date	Reference(s)
Release Samples for SI Sampling Conducted in August 1999				
W-3/CWS38	Municipal Well 3 Inside City Maintenance Garage	Unknown, (well depth 523.94' msl)	August 25, 1999	Ref. 9, p. 9-05, 9-10; Ref. 15, p. 15-10
W-5/CWS39	Municipal Well 5	533.22 to 523.22	August 25, 1999	Ref. 9, p. 9-05, 9-10; Ref. 15, p. 15-15
Release Samples for WVDEP Sampling Conducted in March-April 2002				
PW3/C4026	Municipal Well 3	Unknown, (well depth 523.94' msl)	March 27, 2002	(Ref. 15, p. 15-10; Ref. 39, page 39-19)
DEP 5S/ C4008	Monitoring Well 5S	551.39 to 541.39	March 27, 2002	(Ref. 37, p. 37-25; Ref. 39, page 39-11)
DEP 7/ C4014	Monitoring Well 7	544.14 to 524.14	April 1, 2002	(Ref. 37, page 37-27; Ref. 39, page 39-15)
DEP 8/ C4016	Monitoring Well 8	544.83 to 524.83	April 1, 2002	(Ref. 37, p. 37-28; Ref. 39, page 39-15)

A comparison of the background and release sample concentrations are summarized below.

Background Samples:

Sample ID (Field/Lab)	Hazardous Substance	Concentration (: g/L)	SQL (: g/L)	Reference(s)
Background Samples for SI Sampling Conducted in August 1999				
W-1/CWS35	PCE	ND	0.5	Ref. 9, p. 9-37, 9-99 to 9-102, 9-31 to 9-35
W-4/CWS36	PCE	ND	0.5	Ref. 9, p. 9-38, 9-99 to 9-102, 9-31 to 9-35
W-6/CWS37	PCE	ND	0.5	Ref. 9, p. 9-39, 9-99 to 9-102, 9-31 to 9-35
Background Samples for WVDEP Sampling Conducted in March-April 2002				
PW 1/C4022	PCE	ND	10	Ref. 39, p. 39-19, 39-03 to 39-07, 39-130, 39-131, 39-78 to 39-81; Ref. 22, p. 22-05
PW 4/C4028	PCE	ND	10	Ref. 39, p. 39-19, 39-03 to 39-07, 39-139, 39-140, 39-78 to 39-81; Ref. 22, p. 22-03
PW 1A/ C4032	PCE	ND	10	Ref. 39, p. 39-23, 39-03 to 39-07, 39-145, 39-146; 39-78 to 39-81; Ref. 22, p. 22-05

Key: : g/L = micrograms per liter.
ND = Non-detect.
SQL = Sample Quantitation Limit. The SQL is the quantity of a substance that can be reasonably quantified given the limits for detection for the method of analysis and sample characteristics that may affect quantitation (Reference 1, page 51586). The SQL is derived from the CLP Contract Required Quantitation Limit (CRQL) by adjusting the value to account for sample dilutions and for analysis of a sample volume which differs

from the volume for aqueous samples specified in the applicable CLP Statement of Work (SOW). The SQLs used in this table are equivalent to the Adjusted CRQLs in the CLP SOWs for OLC03.2 and OLM04.2 (Reference 4, pages 4-09, 4-13, 4-11, 4-12; Reference 44, pages 44-05, 44-10, 44-07, 44-08; Reference 41, page 41-01). OLC03.2 has replaced OLC02.1 for analysis of low concentration organics in water, however the CRQL for tetrachlorethene did not change (Reference 40, pages 40-01 to 40-03). Therefore, the calculation for the SQL would be the same for OLC02.1 and OLC03.2 (Reference 4, pages 4-13, 4-09, 4-11; Reference 41, page 41-01). The SQL calculation for OLM04.2 is provided in References 41 and 44 (Reference 41, page 41-01; Reference 44, pages 44-05, 44-10, 44-07, 44-08;). Samples analyzed using OLC02.1: W-1/CWS35; W-4/CWS36; W-6/CWS37. Samples analyzed using OLM04.2: PW 1/C4022; PW 4/C4028; PW 1A/C4032.

Release Samples:

Sample ID (Field/Lab)	Hazardous Substance	Concentration (:g/L)	SQL (:g/L)	Reference(s)
Release Samples for SI Sampling Conducted in August 1999				
W-3/CWS38	PCE	30	1	Ref. 9, p. 9-40, 9-99 to 9-102, 9-31 to 9-35
W-5/CWS39	PCE	14	0.5	Ref. 9, page 9-41, 9-99 to 9-102, 9-31 to 9-35
Release Samples for WVDEP Sampling Conducted in March-April 2002				
DEP 7/ C4014	PCE	130	10	Ref. 39, p. 39-15, 39-122, 39-01 to 39-07, 39-78 to 39-82; Ref. 22, p. 22-07
DEP 8/C4016	PCE	35	10	Ref. 39, p. 39-15, 39-125, 39-01 to 39-07, 39-78 to 39-82; Ref. 22, p. 22-06

Key: :g/L - micrograms per liter
ND - Non-detect
SQL - Sample Quantitation Limit. The SQL is the quantity of a substance that can be reasonably quantified given the limits for detection for the method of analysis and sample characteristics that may affect quantitation (Reference 1, page 51586). The SQL is derived from the CLP Contract Required Quantitation Limit (CRQL) by adjusting the value to account for sample dilutions and for analysis of a sample volume which differs from the volume for aqueous samples specified in the CLP Statement of Work (SOW). The SQLs used in this table are equivalent to the Adjusted CRQLs in the CLP SOWs for OLC03.2 and OLM04.2 (Reference 4, pages 4-09, 4-13, 4-11, 4-12; Reference 44, pages 44-05, 44-10, 44-07, 44-08; Reference 41, page 41-01). OLC03.2 has replaced OLC02.1 for analysis of low concentration organics in water, however the CRQL for tetrachlorethene did not change (Reference 40, pages 40-01 to 40-03). Therefore, the calculation for the SQL would be the same for OLC02.1 and OLC03.2 (Reference 4, pages 4-13, 4-09, 4-11; Reference 41, page 41-01). The SQL calculation for OLM04.2 is provided in References 41 and 44 (Reference 41, page 41-01; Reference 44, pages 44-05, 44-10, 44-07, 44-08;). Samples analyzed using OLC02.1: W-3/CWS38; and W-5/CWS39. Samples analyzed using OLM04.2: DEP 7/C4014; and DEP 8/C4016.

Hazardous Substances Released:

Tetrachloroethene (or PCE)

Attribution

No attribution discussion is included because when the source itself consists of a ground water plume with no identified source, no separate attribution is required (Reference 1, page 51595).

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Observed Release Factor Value: 550

3.1.2 Potential to release

Potential to release was not scored because an observed release to ground water was established by chemical analysis (see Section 3.0 of this documentation record).

3.1.3 Calculation of likelihood of release factor category value

As documented in Section 3.1.1. of this documentation record, an observed release was established to the Quaternary Alluvium aquifer. An observed release factor value of 550 was assigned as the likelihood of release factor category value for the Quaternary Alluvium aquifer.

Likelihood of Release Factor Value: 550
Reference 1, Section 3.1.3, page 51601

3.2 Waste characteristics

3.2.1 Toxicity/mobility

The Ravenswood PCE site was assigned a toxicity/mobility factor value of 100 based on the values assigned to the hazardous substance (PCE) for the toxicity/mobility factors. The hazardous substance with the highest toxicity/mobility factor value for the Quaternary Aquifer is PCE (Reference 1, Section 3.2.1.3, page 51602).

3.2.1.1 Toxicity

A toxicity factor value of 100 was assigned to PCE as specified in Section 2.4.1.1 of the HRS (Reference 1, Section 3.2.1.1, page 51601).

Toxicity Factor Value: 100
Reference 1, Section 3.2.1.1, page 51601; Reference 2, page BI-11

3.2.1.2 Mobility

A mobility factor of 1 was assigned to the hazardous substance PCE because it meets the criteria for an observed release by chemical analysis (Reference 1, Section 3.2.1.2, page 51601).

Ground Water Mobility Factor: 1
Reference 1, Section 3.2.1.2, page 51601

3.2.1.3 Calculation of toxicity/mobility factor value

Hazardous Substance	Source No.	Toxicity Factor Value	Mobility	Toxicity/ Mobility Factor Value	References
PCE	1	100	1	100	Reference 2, p. BI-11

Toxicity/Mobility Factor Value: 100

3.2.2 Hazardous waste quantity

As the PCE concentrations in the release samples exceed the 5 ppb MCL for drinking water, the drinking water targets for the ground water migration pathway are subject to Level I concentrations (Reference 2, page BII-11). Therefore, an HWQ factor value of 100 is assigned (Ref. 1, Section 2.4.2.2).

Source Number	Source Hazardous Waste Quantity Value (Section 2.4.2.1.5)	Is source hazardous constituent quantity data complete? (Yes/No)
1	>0	No
Sum of Values: >0		

3.2.3 Calculation of waste characteristics factor category value

The toxicity/mobility and hazardous waste quantity factor values were multiplied, resulting in a waste quantity factor value of $1x10^4$. Based on this product and Table 2–7, Section 2.4.3.1 of the HRS Rule (Reference 1), a value of 10 was assigned to the waste characteristics factor category.

Toxicity/Mobility Factor Value X Hazardous Waste Quantity Factor Value: 1×10^4

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Hazardous Waste Quantity Factor Value: $1x10^4$
Waste Characteristics Factor Category Value: 10

3.3 Targets

Since the Ravenswood PCE Ground Water Plume site consists solely of a contaminated ground water plume with no identified source, the 4-mile target distance limit was measured at the center of the area of observed ground water contamination. The area of observed ground water contamination was determined based on available samples that meet the criteria for an observed release (Reference 1, Section 3.0.1.1, page 51595). The area of observed ground water contamination is the area between Municipal Wells 3 and 5 in which samples collected during the August 1999 SI met the observed release criteria (Reference 9, pages 9-09, Table 1 [pages 9-16 to 9-19], 9-40, and 9-41). These wells are used as a source of drinking water for the City of Ravenswood and some surrounding areas. See Section 3.3.2 for documentation of the population which uses the well water as a source of drinking water.

The area of observed ground water contamination was further defined during the WVDEP investigation conducted March 27 to April 1, 2002. Analytical results for ground water samples collected indicated an observed release in Municipal Well 3 and also in monitoring wells MW 5D, MW 7, and MW 8 (Reference 39, pages 39-06 to 39-23). The vertical and horizontal extent of the ground water contamination has not been adequately characterized; however, the PCE ground water plume appears to extend from the area of Municipal Well 3 on Virginia Street in a southward direction for approximately 1,400 feet to Broadway Street. The plume width is estimated to be approximately 400 feet wide in the upper portion of the water bearing zone and 100 feet in the lower portion of the water bearing zone (Reference 37, page 37-11). The size of the plume was estimated based on analytical results from the five municipal wells, four monitoring wells installed by EPA, 7 monitoring wells installed by WVDEP, and ground water samples collected from GeoProbe™ borings during the State investigation. The WVDEP investigation also determined that the ground water flow was generally in a northward direction toward the municipal well field. The northerly flow direction is likely a localized condition due to the pumping from the municipal wells (Reference 37, pages 37-09, 37-11).

3.3.1 Nearest Well

Samples from the August 1999 SI from Municipal Wells 3 and 5 meet the criteria for an observed release for these wells, and are subject to Level I concentrations as specified in Section 2.5.1 of the HRS. The concentrations of PCE associated with Municipal Wells 3 and 5 are above the health-based benchmarks from Table 3-10 from Reference 1 (Reference 1; Reference 2, page BII-11). That is, they are above the 5 ppb maximum contaminant level (MCL) benchmark for drinking water. Thus, the nearest well factor was assigned a value of 50 based on drinking water wells subject to Level I concentrations (Reference 1, Section 3.3.1, Table 3-10 and 3-11, page 51603).

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Nearest Well Factor: 50
Reference 1, Section 3.3.1, Table 3-10 and 3-11, page 51603

3.3.2 Population

The plume of ground water contamination includes the area between Municipal Wells 3 and 5 in which samples taken during the August 1999 SI met the observed release criteria (Reference 9, page 9-09, Table 1 [pages 9-16 to 9-19], 9-40, and 9-41). Both municipal and private wells within four miles of the site are used as potable water supplies. All five of the Ravenswood municipal wells are within 0.25 mile of the center of this area of observed ground water contamination (Reference 9, page 9-27).

The blended water supply system for the City of Ravenswood supplies drinking water to a population of approximately 5,453.2 persons. This population was based on the number of residential customers and the population of three schools: Henry J. Kaiser Elementary, Ravenswood High School, and Ravenswood Middle School. The Ravenswood water system provides drinking water to 1,749 residential customers and three schools which have a total of 1,448 students, faculty, and staff (Reference 23, page 23-01; Reference 25, page 25-01; Reference 26, page 26-01). The 1,749 residential households are estimated to have the average number for the City of Ravenswood of 2.29 persons per residence: 1,749 x 2.29 = 4,005.2 persons (Reference 34, page 34-03). Therefore, the City of Ravenswood water system serves a total of 1,448 + 4,005.2 = 5,453.2 persons in the City of Ravenswood. In addition, the system also supplies water to approximately 2,478.5 persons in the Silverton PSD, which includes two elementary schools (Reference 34, page 34-02; Reference 35, page 35-01; and Reference 36, page 36-01). The Silverton population number is based on the number of billing customers and the population of two elementary schools serviced by the PSD. Silverton PSD services 739 residential customers, which includes the two elementary schools: Gilmore Elementary and Eastwood Elementary (Reference 35, page 35-01). The two elementary schools have a total of 631 students, faculty and staff (Reference 36, page 36-01). The remaining 739 billing customers are estimated to have the county average of 2.5 persons per residence: 739 x 2.5 = 1,847.5 persons (Reference 34, page 34-02). Therefore, the Silverton PSD serves a total of 631 + 1,847.5 = 2,478.5 persons. The total population served by the City of Ravenswood water system is 5,453.2 + 2,478.5 = 7,910.7.

In determining the population served by each well within the blended system, the total population of 7,910.7 persons regularly served by the blended system was apportioned equally to each well (Reference 28, page 28-01; Reference 34, pages 34-02 and 34-03; Reference 35, page 35-01; Reference 36, page 36-01; and Reference 1, Section 3.3.2, page 51603). This is based on each well's relative contribution to the total blended system. In estimating the well's relative contribution, it was documented that no well exceeds 40 percent based on average annual pumpage or capacity (Reference 28, page 28-01). Each of the five wells that have contributed to the blended system have been apportioned a population of 1,582.14 (Reference 1, Section 3.3.2, page 51603).

In addition, there is a total population of 1,412 people relying on private wells within the four-mile radius of the site (Reference 14, page 14-08). However, this population is not considered within the target factor value due to lack of information regarding sampling and location of the wells.

HRS scoring will not consider the effects of responses that do not reduce waste quantities such as providing alternate drinking water supplies to populations with drinking water supplies

contaminated by the site. In such cases, the initial targets factor is used to reflect the adverse impacts caused by contamination of drinking water supplies; otherwise, a contaminated aquifer could be artificially shielded from further remediation (Reference 1, pages 51567 and 51568).

3.3.2.1 Level of contamination

3.3.2.2 Level I concentrations

PCE was detected at a concentration of 30 ：g/L in release sample W-3, and at 14 ：g/L in release sample W-5 (Reference 9, page 9-09). The number of people served by drinking water from points of withdrawal subject to Level I concentrations (Municipal Wells 3 and 5) is 3,164.28 (1,582.14 x 2). The sum of 3,164.28 is multiplied by 10 based on Level I concentrations and is the assigned value for this factor (Reference 1, Section 3.3.2.2, page 51603).

Level I Concentrations: 31,642.8
Reference 1, Section 3.3.2.2, page 51603

3.2.3 Level II concentrations

No Level II concentrations are evaluated in this documentation record.

3.3.2.4 Potential contamination

Municipal Wells 1, 2, and 4 of the Ravenswood municipal wells are within 0.25 mile of the center of the area of observed ground water contamination (Reference 9, page 9-27). Each well supply has been apportioned a population of 1,582.14. A total number of people served in the 0-1/4 mile distance ring that have not been counted under Level I or Level II concentration is 4,746.42. Using Table 3-12 of the HRS, page 51604, a distance-weighted population value of 5,214 was assigned to the 0-1/4 mile distance ring (HRS, Section 3.3.2.4, pages 51603 and 51604). No other data regarding the depth and location for the private wells within the 4-mile target distance limit were available, and these were not considered in the potential contamination factor.

The distance-weighted population was multiplied by one tenth to produce a value of 521.4 for the 0-1/4 distance category was assigned based on the number of people included within the distance category that could be potentially be drinking contaminated water (Reference 1, Section 3.3.2.5, Table 3-12, page 51604).

Potential Contamination Value: 521.4
Reference 1, Section 3.3.2.4, page 51604

3.3.2.5 Calculation of population factor value

The sum of the factor values for Level I concentrations (31,642.8), Level II concentrations (0), and potential contamination (521.4) is 32,164.2. The sum of 32,164.2 is assigned as the population factor value for the aquifer (Reference 1, Section 3.3.2.5, page 51604).

Population Factor Value: 32,164.2
Reference 1, Section 3.3.2.5, page 51604

3.3.3 Resources

No uses other than drinking water and industrial process water were identified (Reference 1, Section 3.3.3.5).

Resources Factor Value: 0

3.3.4 Wellhead Protection Area

A wellhead protection area exists in the City of Ravenswood (Reference 3). All the municipal wells and the currently known extent of the Ravenswood PCE Ground Water Plume Site are located within the wellhead protection area (Reference 1, Section 3.3.4; Reference 3, pages 3-01, 3-02; Figure 2).

Wellhead Protection Area Factor Value: 20

3.3.5 Calculation of targets factor category value

The sum for the factor values for nearest well, population, resources, and wellhead protection area is 32,234.2. This sum is the targets factor category value for the Quaternary Aquifer.

Targets Factor Category Value: 32,234.2
Reference 1, Section 3.3.5, page 51604

3.4 Ground water migration score for an aquifer

The factor category values for likelihood of release (550), waste characteristics (10), and targets (32,234.2) have been multiplied, and rounded to the nearest integer of 177,288,100. This number is divided by 82,500 for a ground water migration score of 2148.9. This is subject to a maximum value of 100 for the Quaternary Alluvium aquifer.

Ground Water Pathway Score for the Quaternary Alluvium Aquifer: 100
Reference 1, Section 3.4, page 51604